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Computational fluid dynamics simulations of discharge capillary waveguides at FLASHForward for high-repetition-rate plasma-wakefield accleration

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Plasma-wakefield accelerators provide acceleration gradients several orders of magnitude larger than conventional accelerators and as such, represent a promising technology for reducing the footprint of future particle accelerators. The luminosity in colliders and the brilliance in free-electron lasers, scales with the repetition rate at which the accelerator operates. Therefore, repetition rate is a crucial parameter to consider when developing plasma-based accelerators for these applications. FLASHForward is an experimental, beam-driven, plasma-accelerator facility at DESY that is unique in the field due to it's ability to probe high-repetition-rate operation. To fully realise FLASHForward's potential it is crucial to develop a plasma source capable of providing consistent plasma properties at megahertz repetition rates. To do this we must gain a better understanding of the plasma dynamics inside the existing discharge-capillary waveguides used at FLASHForward with the aim of improving the designs in the future. The first step required is to optimise the gas flow in the capillaries to achieve repeatable plasma conditions at high repetition rate. In this contribution, computational fluid dynamics simulations in discharge capillaries are presented, revealing both a better understanding of gas flow in existing designs as well as hints as to how designs may be optimised in the future.

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